ECO 745: Theory of International Economics

Jack Rossbach

Fall 2015 - Lecture 13

Eaton and Kortum (2002)

Brief recap of last week. Basic framework is:

- Continuum of goods $j \in [0,1]$
- $i, n = 1,2, \ldots, N$ countries
- Country unit input costs: c_i
- Good specific productivity in country i: $z_i(j) \Rightarrow$ cost of producing good j in country i is $c_i / z_i(j)$
- Iceburg trade costs: $d_{ni} > 1$ for $i \neq n$ $(d_{ii} = 1)$
- Perfect competition $\Rightarrow$ price charged by firms in country i to consumers in country n for good j

$$p_{ni}(j) = \left(\frac{c_i}{z_i(j)}\right) d_{ni}$$

Consumers and Prices

Consumers have CES preferences over goods

$$U_n = \left[\int_0^1 \left(Q_n(j)\right)^{\frac{\sigma-1}{\sigma}} dj\right]^{\frac{\sigma}{\sigma-1}}$$

Total expenditures of country n are X_n

$$\int_0^1 p_n(j) Q_n(j) dj = X_n$$

The price of good j in country n is the minimum price across producers in all countries

$$p_n(j) = \min\{p_{n1}(j), p_{n2}(j), \dots, p_{nN}(j)\}$$

$$= \min\left\{\left(\frac{c_1}{z_1(j)}\right) d_{n1}, \left(\frac{c_2}{z_2(j)}\right) d_{n2}, \dots, \left(\frac{c_N}{z_N(j)}\right) d_{nN}\right\}$$

Frechet Productivity Distribution

Assume productivity in country i follows a Frechet(T_i, θ) distribution

$$F_i(z) = P(Z \leq z) = e^{-T_i z^{-\theta}}$$

- $T_i > 0$ governs the location of the productivity distribution for country i.
  - Higher $T_i \Rightarrow$ higher productivity draw more likely for any good j
- $\theta > 0$ governs variation in the productivity distribution (common across countries)
  - Higher $\theta \Rightarrow$ less variability across goods (governs degree of comparative advantage)
  - $\mathrm{sd}[\log z] = \pi/(\theta\sqrt{6})$; Geometric Mean $= e^{\gamma/\sigma} T_i^{1/\theta}$ ($\gamma \approx .577$, Euler's constant)

Key Property of Frechet Productivity Distribution

Why the Frechet distribution?

- The Frechet distribution is an Extreme Value (type II) distribution and is *max stable*
- Suppose $Z_1, Z_2, \ldots, Z_N$ follow Frechet(T_i, θ) distributions. Define $Z_{\max} = \max\{Z_1, Z_2, \ldots, Z_N\}$, then

$$F_{\max}(z) = e^{-\sum_{i=1}^{N} T_i z^{\theta}} = e^{-z^{\theta}\sum_{i=1}^{N} T_i}$$

So therefore $Z_{\max} \sim \text{Frechet}\left(\sum_{i=1}^{N} T_i, \theta\right)$

Distribution of Prices

- Define $G_{ni}(p)$ as the proportion of prices offered by country i to country n that are less than p

$$G_{ni}(p) = \Pr(P_{ni} < p) = \Pr\left(Z > \frac{c_i}{p} d_{ni}\right) = 1 - F_i(c_i d_{ni}/p) = 1 - e^{-T_i (c_i d_{ni})^{-\theta} p^{\theta}}$$

- Let $G_n(p)$ be share of (minimal) prices offered in country n that are less than p

$$G_n(p) = 1 - \prod_{i=1}^{N} \big(1 - G_{ni}(p)\big) = 1 - e^{-\Phi_n p^{\theta}}, \qquad \text{where } \Phi_n = \sum_{i=1}^{N} T_i (c_i d_{ni})^{-\theta}$$

- The probability that country i is the lowest cost producer of good j to country n, π_{ni}, is

$$\pi_{ni} = \int_0^{\infty} \overbrace{\prod_{\substack{s=1 \\ s \neq i}}^{N} \Pr(P_{ns} > p)}^{\text{Prob. no other country offers a price less than } p} \; \overbrace{d \Pr(P_{ni} \leq p)}^{\text{Prob. country } i \text{ offers a price} \leq p} \; \pi_{ni} = \frac{T_i (c_i d_{ni})^{-\theta}}{\Phi_n}$$

CES Price Index

The CES Price index can be derived as

$$p_n = \left(\int_0^1 \left(p_n(j) \right)^{1-\sigma} dj \right)^{\frac{1}{1-\sigma}} = \gamma (\Phi_n)^{-\frac{1}{\theta}}$$

Where

$$\gamma = \left[\Gamma \left(\frac{\theta + 1 - \sigma}{\theta} \right) \right]^{\frac{1}{1-\sigma}}$$

and $\Gamma[t]$ is the Gamma function

$$\Gamma(t) = \int_0^\infty x^{t-1} e^{-x} dx$$

Aggregate Bilateral Trade Flows

Distribution of prices is independent of origin of lowest cost producer

- Can compute fraction of country n's expenditure on goods from country i

$$\frac{X_{ni}}{X_n} = \pi_{ni} = \frac{T_i(c_i d_{ni})^{-\theta}}{\Phi_n}$$

- Let $Q_i = \sum_{m=1}^{N} X_{mi}$, then get the following gravity type relationship for trade flows

$$X_{ni} = \frac{\left(\frac{d_{ni}}{p_n}\right)^{-\theta} X_n}{\left(\sum_{m=1}^{N} \left(\frac{d_{mi}}{p_m}\right)^{-\theta} X_m\right)} Q_i$$

Closing the Model

Previous discussion takes input costs as given, but they should be affected by trade

Suppose that production uses a Cobb-Douglas aggregate of labor and intermediate inputs:

$$y_{ni}(j) = \frac{1}{d_{ni}} z_i(j) \overbrace{\left(l_{ni}(j)\right)^{\beta} \left(q_{ni}(j)\right)^{1-\beta}}^{\text{input bundle}}$$

Where $q_{ni}(j)$ is a CES aggregate of intermediate goods, $q_{ni}^{j}(j')$, used in the production of j

$$q_{ni}(j) = \left[\int_0^1 \left(q_{ni}^{j}(j')\right)^{\frac{\sigma-1}{\sigma}} dj'\right]^{\frac{\sigma}{\sigma-1}}$$

Closing the Model

Previous discussion takes input costs as given, but they should be affected by trade

Suppose that production uses a Cobb-Douglas aggregate of labor and intermediate inputs:

$$y_{ni}(j) = \frac{1}{d_{ni}} z_i(j) \overbrace{\left(l_{ni}(j)\right)^{\beta} \left(q_{ni}(j)\right)^{1-\beta}}^{\text{input bundle}}$$

Where $q_{ni}(j)$ is a CES aggregate of intermediate goods, $q_{ni}^{j}(j')$, used in the production of j

$$q_{ni}(j) = \left[\int_0^1 \left(q_{ni}^{j}(j')\right)^{\frac{\sigma-1}{\sigma}} dj'\right]^{\frac{\sigma}{\sigma-1}}$$

This implies that the cost of an input bundle in country i will be equal to

$$c_i = w_i^{\beta} p_i^{1-\beta}$$

Where w_i is wages and p_i is the same CES price index derived earlier

Real Wage vs Domestic Share of Consumption

$$c_i = w_i^{\beta} p_i^{1-\beta}$$

Where w_i is wages and p_i is the same CES price index derived earlier. Combining the above with

$$p_i = \gamma(\Phi_n)^{-\frac{1}{\theta}} \quad \Rightarrow \quad \Phi_i = (p_i)^{-\theta}\gamma^{\theta}$$

$$\pi_{ni} = \frac{X_{ni}}{X_n} = \frac{T_i(c_i d_{ni})^{-\theta}}{\Phi_n} \quad \Rightarrow \quad \pi_{ii} = \frac{T_i(c_i)^{-\theta}}{\Phi_i}$$

Yields the following expression that can be used to deliver the relative wage

$$\pi_{ii} = \frac{T_i\left(w_i^{\beta} p_i^{1-\beta}\right)^{-\theta}}{(p_i)^{-\theta}\gamma^{\theta}} \quad \Rightarrow \quad \frac{w_i}{p_i} = \gamma^{-\frac{1}{\beta}}\left(\frac{T_i}{\pi_{ii}}\right)^{\frac{1}{\beta\theta}}$$

Real Wage vs Domestic Share of Consumption

$$c_i = w_i^{\beta} p_i^{1-\beta}$$

Where w_i is wages and p_i is the same CES price index derived earlier. Combining the above with

$$p_i = \gamma(\Phi_n)^{-\frac{1}{\theta}} \quad \Rightarrow \quad \Phi_i = (p_i)^{-\theta}\gamma^{\theta}$$

$$\pi_{ni} = \frac{X_{ni}}{X_n} = \frac{T_i(c_i d_{ni})^{-\theta}}{\Phi_n} \quad \Rightarrow \quad \pi_{ii} = \frac{T_i(c_i)^{-\theta}}{\Phi_i}$$

Yields the following expression that can be used to deliver the relative wage

$$\pi_{ii} = \frac{T_i\left(w_i^{\beta} p_i^{1-\beta}\right)^{-\theta}}{(p_i)^{-\theta}\gamma^{\theta}} \quad \Rightarrow \quad \frac{w_i}{p_i} = \gamma^{-\frac{1}{\beta}}\left(\frac{T_i}{\pi_{ii}}\right)^{\frac{1}{\beta\theta}}$$

Note that if the real wage is higher, welfare will be higher. Can compare real wage to autarky real wage by noting that $\pi_{ii}^{\text{autarky}} = 1$. Conditional on observed π_{ii}, welfare gains higher if $\theta, \beta \downarrow$

Equilibrium Prices

Plugging in input cost to price level yields:

$$p_n = \gamma(\Phi_n)^{-\frac{1}{\theta}} = \gamma\left(\sum_{i=1}^{N} T_i(c_i d_{ni})^{-\theta}\right)^{-\frac{1}{\theta}} = \gamma\left(\sum_{i=1}^{N} T_i\left(w_i^{\beta} p_i^{1-\beta} d_{ni}\right)^{-\theta}\right)^{-\frac{1}{\theta}}$$

Which, given w_i, generally needs to be solved numerically for the p_i's. We can also write

$$\frac{X_{ni}}{X_n} = \pi_{ni} = T_i\left(\frac{\gamma d_{ni} w_i^{\beta} p_i^{1-\beta}}{p_n}\right)^{-\theta}$$

Labor Market Equilibrium

Labor income is equal to labor's share of value of output

$$w_i L_i = \beta Q_i = \beta \sum_{n=1}^{N} X_{ni} = \beta \sum_{n=1}^{N} \pi_{ni} X_n$$

Total expenditures in country n are

$$X_n = \overbrace{\frac{1-\beta}{\beta} w_n L_n}^{\text{intermediate inputs}} + \overbrace{w_n L_n}^{\text{final consumption}} = \frac{1}{\beta} w_n L_n$$

Wages therefore satisfy

$$w_i L_i = \sum_{n=1}^{N} \pi_{ni} w_n L_n$$

Solving Equilibrium

The equilibrium is pinned down by the following sets of equations

$$w_i L_i = \sum_{n=1}^{N} \pi_{ni} w_n L_n , \qquad i = 1,2, \dots , N$$

$$\pi_{ni} = T_i \left(\frac{\gamma d_{ni} w_i^{\beta} p_i^{1-\beta}}{p_n} \right)^{-\theta} , \qquad i, n = 1,2, \dots , N$$

$$p_n = \gamma \left[\sum_{i=1}^{N} T_i \left(d_{ni} w_i^{\beta} p_i^{1-\beta} \right)^{-\theta} \right]^{-\frac{1}{\theta}} , \qquad n = 1,2, . . , N$$

In general, this system of equations needs to be solved numerically

Special Case: Free Trade

Under free trade $d_{ni} = 1 \; \forall i, n$.

Therefore good prices are equalized across countries, $p_i = p_n \forall i, n$, which means

$$\pi_{ni} = T_i \left(\gamma w_i^{\beta} p_i^{-\beta}\right)^{-\theta}$$

And therefore

$$\frac{w_i L_i}{w_n L_n} = \frac{\pi_i \sum_{m=1}^{N} w_m L_m}{\pi_n \sum_{m=1}^{N} w_m L_m} = \frac{T_i \left(\gamma w_i^{\beta} p_i^{-\beta}\right)^{-\theta}}{T_n \left(\gamma w_n^{\beta} p_n^{-\beta}\right)^{-\theta}} = \frac{T_i \left(\gamma w_i^{\beta}\right)^{-\theta}}{T_n \left(\gamma w_n^{\beta}\right)^{-\theta}}$$

Rearranging gives

$$\frac{w_i}{w_n} = \left(\frac{T_i / L_i}{T_n / L_n}\right)^{\frac{1}{1+\theta\beta}}$$

Special Case: Free Trade

Price is same for all countries and determined by

$$p_n = \gamma \left[\sum_{i=1}^{N} T_i \left(w_i^{\beta} p_i^{1-\beta} \right)^{-\theta} \right]^{-\frac{1}{\theta}} = \gamma \left[\sum_{i=1}^{N} T_i \left(w_i^{\beta} p_n^{1-\beta} \right)^{-\theta} \right]^{-\frac{1}{\theta}}$$

Rearranging and substituting in relative wages gives

$$p_n^{\beta} = \gamma \left[\sum_{i=1}^{N} T_i \left(w_i^{\beta} \right)^{-\theta} \right]^{-\frac{1}{\theta}} = \gamma \left[\sum_{i=1}^{N} T_i \left(\left(w_n \left(\frac{T_i/L_i}{T_n/L_n} \right)^{\frac{1}{1+\theta\beta}} \right)^{\beta} \right)^{-\theta} \right]^{-\frac{1}{\theta}}$$

Solving for relative wages yields

$$\frac{w_n}{p_n} = \gamma^{-\frac{1}{\beta}} T_n^{\frac{1}{1+\theta\beta}} \left[\sum_{i=1}^{N} T_i^{\frac{1}{1+\theta\beta}} (L_k/L_i)^{\frac{\theta\beta}{1+\theta\beta}} \right]^{\frac{1}{\theta\beta}}$$

Special Case: Free Trade — Real Wage Discussion

Note that real wages equal Real GDP per capita as GDP is $w_i L_i$. From our formula we have

$$\frac{w_n}{p_n} = \gamma^{-\frac{1}{\beta}} T_n^{\frac{1}{1+\theta\beta}} \left[\sum_{i=1}^{N} T_i^{\frac{1}{1+\theta\beta}} (L_i/L_n)^{\frac{\theta\beta}{1+\theta\beta}} \right]^{\frac{1}{\theta\beta}}$$

Therefore country n's GDP per capita increases under free trade if:

- Its average productivity increases ($T_n \uparrow$), both because the demand for country n's labor increases and goods become cheaper
- Other countries average productivity increases ($T_i \uparrow, i \neq j$) as goods become cheaper. Note this impact scales with the size of the labor force for the foreign country.

Special Case: Autarky

In autarky $d_{ni} = \infty \; \forall n \neq i$, while $d_{ii} = 1$. Therefore $\pi_{ii} = 1$ and the third equation becomes

$$p_i = \gamma \left[T_i \left(w_i^{\beta} p_i^{1-\beta} \right)^{-\theta} \right]^{-\frac{1}{\theta}}$$

Which rearranges to give the autarky real wage

$$\frac{w_i^{\text{aut}}}{p_i^{\text{aut}}} = \gamma^{-\frac{1}{\beta}} T_i^{\frac{1}{\beta\theta}}$$

Special Case: Autarky

In autarky $d_{ni} = \infty \; \forall n \neq i$, while $d_{ii} = 1$. Therefore $\pi_{ii} = 1$ and the third equation becomes

$$p_i = \gamma \left[T_i \left(w_i^{\beta} p_i^{1-\beta} \right)^{-\theta} \right]^{-\frac{1}{\theta}}$$

Which rearranges to give the autarky real wage

$$\frac{w_i^{\text{aut}}}{p_i^{\text{aut}}} = \gamma^{-\frac{1}{\beta}} T_i^{\frac{1}{\beta\theta}}$$

Note every country is better off under free trade as

$$\frac{w_n}{p_n} = \gamma^{-\frac{1}{\beta}} T_n^{\frac{1}{1+\theta\beta}} \left[\sum_{i=1}^{N} T_i^{\frac{1}{1+\theta\beta}} (L_i/L_n)^{\frac{\theta\beta}{1+\theta\beta}} \right]^{\frac{1}{\theta\beta}} = \gamma^{-\frac{1}{\beta}} T_n^{\frac{1}{\theta\beta}} \overbrace{\left[\sum_{i=1}^{N} (T_i/T_n)^{\frac{1}{1+\theta\beta}} (L_i/L_n)^{\frac{\theta\beta}{1+\theta\beta}} \right]^{\frac{1}{\theta\beta}}}^{>1 \text{ as it includes } i=n}$$

Counterfactuals and Model Parameters

Need to estimate parameters of model in order to perform counterfactuals

- First need an estimate of θ
  - Several ways to estimate, depending on data availability (see paper). Will present the default.
- Then, given θ, can estimate T_i (technology) and d_{ni} (geography)
- Can use parameter estimates to perform counterfactuals such as gains from moving from autarky to implied trade costs, or additional gains from moving to a frictionless world/further reducing trade costs.

Estimating Theta: Pricing Data

Can express country n's import share from i relative to country i's domestic consumption as

$$\frac{X_{ni}/X_n}{X_{ii}/X_i} = \left(\frac{p_i d_{ni}}{p_n}\right)^{-\theta}$$

Which provides a relationship between normalized trade share and prices

- Use data on normalized import shares from 19 OECD countries in 1990
- Could use distance as a proxy for d_{ni}
- Pricing data on 100 products across the 19 OECD countries

Estimating the Model's Gravity Equation: Pricing Data

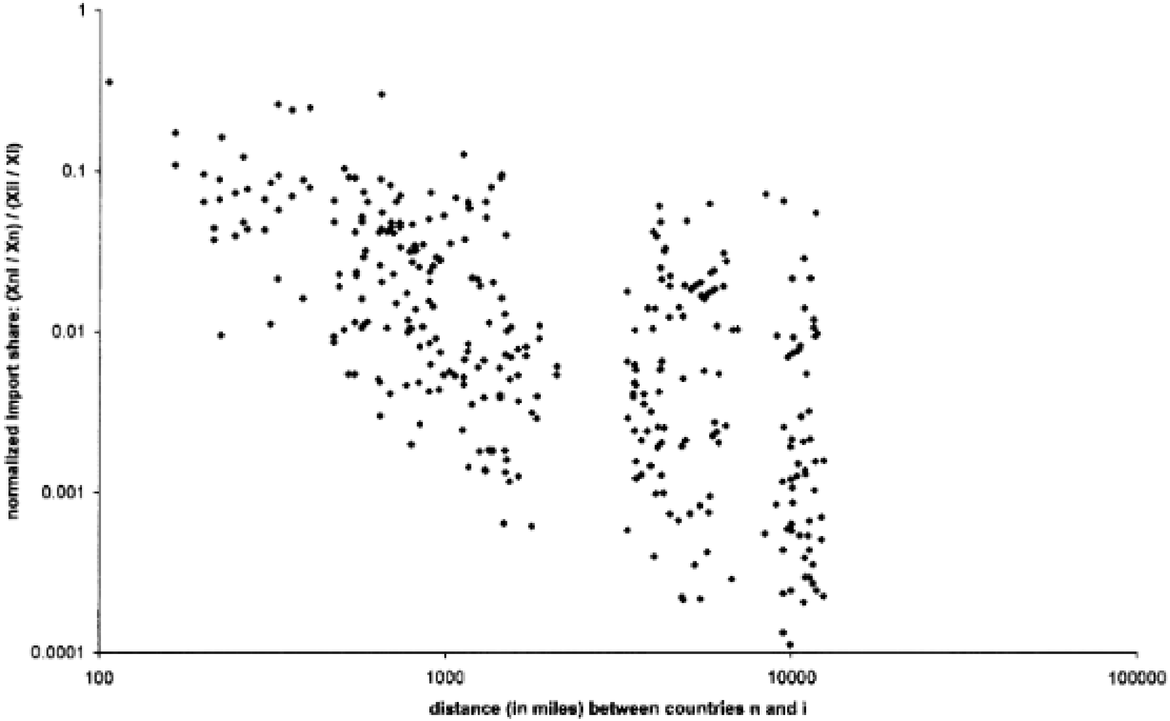

FIGURE 1.—Trade and geography.

EK(2002)

Estimating Theta: Pricing Data

Can express country n's import share from i relative to country i's domestic consumption as

$$\frac{X_{ni}/X_n}{X_{ii}/X_i} = \left(\frac{p_i d_{ni}}{p_n}\right)^{-\theta}$$

Which provides a relationship between normalized trade share and prices

- Use data on normalized import shares from 19 OECD countries in 1990
- Could use distance as a proxy for d_{ni}, but distance potentially confounds θ and d_{ni}
- Pricing data on 50 products across the 19 OECD countries: use to estimate $p_i d_{ni}/p_n$

Estimating Theta: Pricing Data

Compute logged relative prices for each country pair and good

$$r_{ni}(j) = \log p_n(j) - \log p_i(j)$$

Estimate

$$\frac{p_i}{p_n} = \text{Mean}\big(-r_{ni}(j)\big)$$

Estimating Theta: Pricing Data

Compute logged relative prices for each country pair and good

$$r_{ni}(j) = \log p_n(j) - \log p_i(j)$$

Estimate

$$\frac{p_i}{p_n} = \text{Mean}\big(-r_{ni}(j)\big)$$

To estimate distance, note in model $r_{ni}(j) \leq d_{ni}\ \forall j$, as otherwise n could import good j from i and have $r_{ni}(j) = d_{ni}$

Estimate d_{ni} as the (second) highest value of r_{ni} across j, so

$$D_{ni} \coloneqq \log\left(\frac{p_i d_{ni}}{p_n}\right) = \frac{\underset{\mathrm{j}}{\text{2ndmax}}\,\{r_{ni}(j)\}}{\sum_{j=1}^{50}[r_{ni}(j)]/50}$$

D_{ni} Estimate Ranges

PRICE MEASURE STATISTICS

Country	Foreign Sources		Foreign Destinations	
	Minimum	Maximum	Minimum	Maximum
Australia (AL)	NE (1.44)	PO (2.25)	BE (1.41)	US (2.03)
Austria (AS)	SW (1.39)	NZ (2.16)	UK (1.47)	JP (1.97)
Belgium (BE)	GE (1.25)	JP (2.02)	GE (1.35)	SW (1.77)
Canada (CA)	US (1.58)	NZ (2.57)	AS (1.57)	US (2.14)
Denmark (DK)	FI (1.36)	PO (2.21)	NE (1.48)	US (2.41)
Finland (FI)	SW (1.38)	PO (2.61)	DK (1.36)	US (2.87)
France (FR)	GE (1.33)	NZ (2.42)	BE (1.40)	JP (2.40)
Germany (GE)	BE (1.35)	NZ (2.28)	BE (1.25)	US (2.22)
Greece (GR)	SP (1.61)	NZ (2.71)	NE (1.48)	US (2.27)
Italy (IT)	FR (1.45)	NZ (2.19)	AS (1.46)	JP (2.10)
Japan (JP)	BE (1.62)	PO (3.25)	AL (1.72)	US (3.08)
Netherlands (NE)	GE (1.30)	NZ (2.17)	DK (1.39)	NZ (2.01)
New Zealand (NZ)	CA (1.60)	PO (2.08)	AL (1.64)	GR (2.71)
Norway (NO)	FI (1.45)	JP (2.84)	SW (1.36)	US (2.31)
Portugal (PO)	BE (1.49)	JP (2.56)	SP (1.59)	JP (3.25)
Spain (SP)	BE (1.39)	JP (2.47)	NO (1.51)	JP (3.05)
Sweden (SW)	NO (1.36)	US (2.70)	FI (1.38)	US (2.01)
United Kingdom (UK)	NE (1.46)	JP (2.37)	FR (1.52)	NZ (2.04)
United States (US)	FR (1.57)	JP (3.08)	CA (1.58)	SW (2.70)

EK(2002)

Estimating Theta: Pricing Data

Estimate the following regression:

$$\log\left(\frac{X_{ni}/X_n}{X_{ii}/X_i}\right) = -\theta D_{ni}$$

Import shares from bilateral trade data, noting $X_{ii} = X_i - \sum_{\substack{n=1 \\ n \neq i}}^{N} X_{ni}$

Yields an estimate of $\theta = 8.28$

Trade Shares vs D_{ni} Estimates

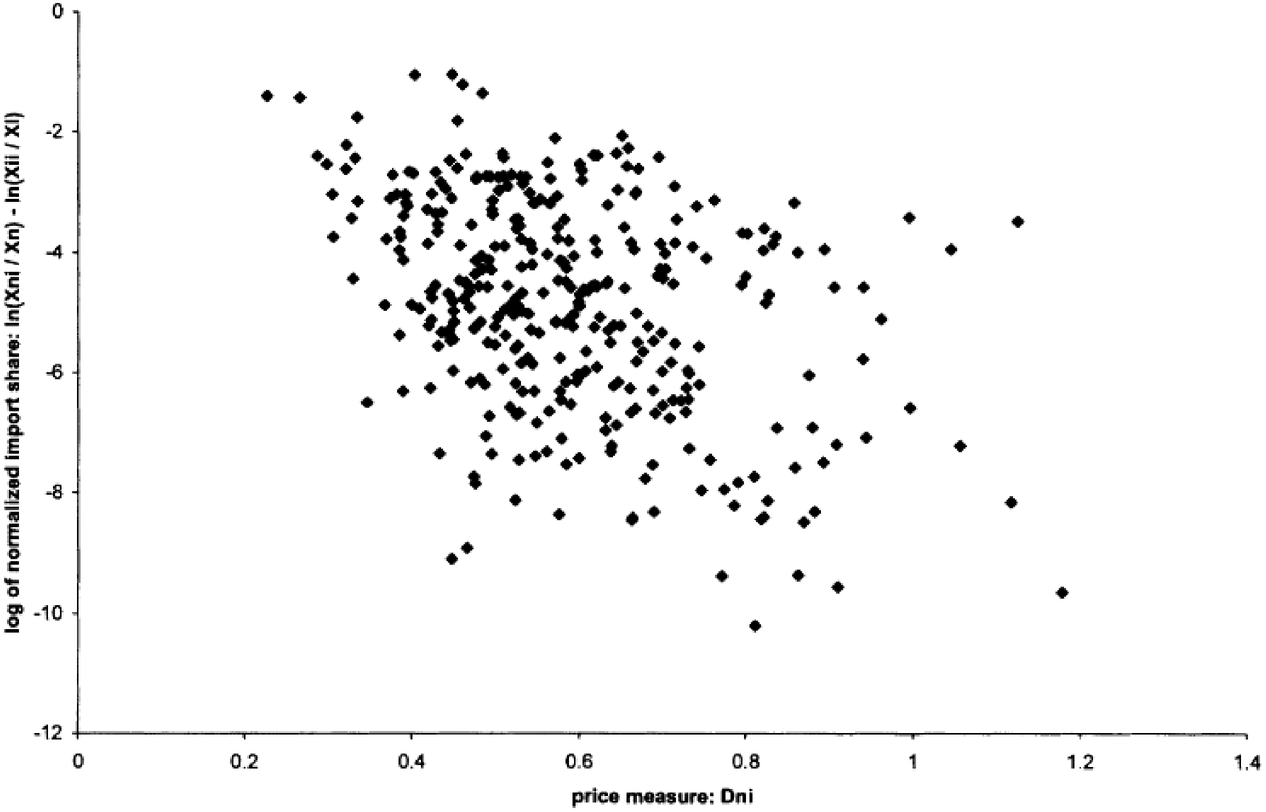

FIGURE 2.—Trade and prices.

EK(2002)

Estimating the Model's Gravity Equation

Recall $\frac{X_{ni}}{X_n} = \pi_{ni} = T_i \left(\frac{\gamma d_{ni} w_i^{\beta} p_i^{1-\beta}}{p_n} \right)^{-\theta}$. Note that we can normalize imports by domestic sales to get

$$\frac{X_{ni}}{X_{nn}} = \frac{T_i}{T_n} \left(\frac{w_i}{w_n} \right)^{-\theta\beta} \left(\frac{p_i}{p_n} \right)^{-\theta(1-\beta)} d_{ni}^{-\theta}$$

And we also have from combining $\frac{X_{nn}}{X_n}$ and $\frac{X_{ii}}{X_i}$ that

$$\frac{p_i}{p_n} = \frac{w_i}{w_n} \left(\frac{T_i}{T_n} \right)^{-\frac{1}{\theta\beta}} \left(\frac{X_i / X_{ii}}{X_n / X_{nn}} \right)^{-\frac{1}{\theta\beta}}$$

Estimating the Model's Gravity Equation

Combining the previous two equations and taking logs yields

$$\log \frac{X'_{ni}}{X'_{nn}} = -\theta d_{ni} + \frac{1}{\beta} \log \frac{T_i}{T_n} - \theta \log \frac{w_i}{w_n}$$

Where $\log X'_{ni} \coloneqq \log X_{ni} - [(1-\beta)/\beta] \log(X_i/X_{ii})$.

Note if we define $S_i \coloneqq \frac{1}{\beta} \log T_i - \theta \log w_i$, then the gravity equation becomes

$$\log \frac{X'_{ni}}{X'_{nn}} = -\theta \log d_{ni} + S_i - S_n$$

Where S_i is country i's "competitiveness," or technology adjusted for labor costs

Estimating the Model's Gravity Equation

$$\log \frac{X'_{ni}}{X'_{nn}} = -\theta \log d_{ni} + S_i - S_n$$

- Can compute $\log \frac{X'_{ni}}{X'_{nn}}$ from bilateral trade data (with $\beta = 0.21$, the average labor share in sample)

- S_i and S_n are estimated with country fixed effects

- Still have problem with distance, estimate following gravity literature

$$\log d_{ni} = d_k + b + l + e_h + m_h + \delta_{ni}$$

- Where d_k, $k = 1, \ldots, 6$, is a distance range; b is a shared border; l is a shared language; e_h is if both are in a shared trading area ($h = 1 \Rightarrow$ European Community, $h = 2 \Rightarrow$ European Free Trade Area); m_n is a destination effect, and δ_{ni} is the error term

Bilateral Gravity Equation Estimates

BILATERAL TRADE EQUATION

Variable		est.	s.e.
Distance [0, 375)	$-\theta d_1$	−3.10	(0.16)
Distance [375, 750)	$-\theta d_2$	−3.66	(0.11)
Distance [750, 1500)	$-\theta d_3$	−4.03	(0.10)
Distance [1500, 3000)	$-\theta d_4$	−4.22	(0.16)
Distance [3000, 6000)	$-\theta d_5$	−6.06	(0.09)
Distance [6000, maximum]	$-\theta d_6$	−6.56	(0.10)
Shared border	$-\theta b$	0.30	(0.14)
Shared language	$-\theta l$	0.51	(0.15)
European Community	$-\theta e_1$	0.04	(0.13)
EFTA	$-\theta e_2$	0.54	(0.19)

EK(2002)

Bilateral Gravity Equation Estimates

Country		Source Country est.	s.e.		Destination Country est.	s.e.
Australia	S_1	0.19	(0.15)	$-\theta m_1$	0.24	(0.27)
Austria	S_2	−1.16	(0.12)	$-\theta m_2$	−1.68	(0.21)
Belgium	S_3	−3.34	(0.11)	$-\theta m_3$	1.12	(0.19)
Canada	S_4	0.41	(0.14)	$-\theta m_4$	0.69	(0.25)
Denmark	S_5	−1.75	(0.12)	$-\theta m_5$	−0.51	(0.19)
Finland	S_6	−0.52	(0.12)	$-\theta m_6$	−1.33	(0.22)
France	S_7	1.28	(0.11)	$-\theta m_7$	0.22	(0.19)
Germany	S_8	2.35	(0.12)	$-\theta m_8$	1.00	(0.19)
Greece	S_9	−2.81	(0.12)	$-\theta m_9$	−2.36	(0.20)
Italy	S_{10}	1.78	(0.11)	$-\theta m_{10}$	0.07	(0.19)
Japan	S_{11}	4.20	(0.13)	$-\theta m_{11}$	1.59	(0.22)
Netherlands	S_{12}	−2.19	(0.11)	$-\theta m_{12}$	1.00	(0.19)
New Zealand	S_{13}	−1.20	(0.15)	$-\theta m_{13}$	0.07	(0.27)
Norway	S_{14}	−1.35	(0.12)	$-\theta m_{14}$	−1.00	(0.21)
Portugal	S_{15}	−1.57	(0.12)	$-\theta m_{15}$	−1.21	(0.21)
Spain	S_{16}	0.30	(0.12)	$-\theta m_{16}$	−1.16	(0.19)
Sweden	S_{17}	0.01	(0.12)	$-\theta m_{17}$	−0.02	(0.22)
United Kingdom	S_{18}	1.37	(0.12)	$-\theta m_{18}$	0.81	(0.19)
United States	S_{19}	3.98	(0.14)	$-\theta m_{19}$	2.46	(0.25)
Total Sum of squares	2937			Error Variance:		
Sum of squared residuals	71			Two-way ($\theta^2 \sigma_2^2$)		0.05
Number of observations	342			One-way ($\theta^2 \sigma_1^2$)		0.16

EK(2002)

Estimating Technology and Distance

To estimate technology parameters, note that

$$S_i \coloneqq \frac{1}{\beta} \log T_i - \theta \log w_i$$

- Use estimated $\beta = 0.21$ from average labor share, estimate $\theta = 8.21$ from before, and then wage data (adjusted for education) for w_i.

- Then T_i is given by the estimate of S_i from the gravity regression.

- For trade costs (geography effects), plug in errors from gravity regression into d_{ni} regression

$$\log d_{ni} = d_k + b + l + e_h + m_h + \delta_{ni}$$

Technology Parameter Estimates

STATES OF TECHNOLOGY

Country	Estimated Source-country Competitiveness	Implied States of Technology $\theta = 8.28$	$\theta = 3.60$	$\theta = 12.86$
Australia	0.19	0.27	0.36	0.20
Austria	−1.16	0.26	0.30	0.23
Belgium	−3.34	0.24	0.22	0.26
Canada	0.41	0.46	0.47	0.46
Denmark	−1.75	0.35	0.32	0.38
Finland	−0.52	0.45	0.41	0.50
France	1.28	0.64	0.60	0.69
Germany	2.35	0.81	0.75	0.86
Greece	−2.81	0.07	0.14	0.04
Italy	1.78	0.50	0.57	0.45
Japan	4.20	0.89	0.97	0.81
Netherlands	−2.19	0.30	0.28	0.32
New Zealand	−1.20	0.12	0.22	0.07
Norway	−1.35	0.43	0.37	0.50
Portugal	−1.57	0.04	0.13	0.01
Spain	0.30	0.21	0.33	0.14
Sweden	0.01	0.51	0.47	0.57
United Kingdom	1.37	0.49	0.53	0.44
United States	3.98	1.00	1.00	1.00

EK(2002)

Geographic Barrier Estimates (effect on d_{ni})

GEOGRAPHIC BARRIERS

Source of Barrier	Estimated Geography Parameters	Implied Barrier's % Effect on Cost		
		$\theta = 8.28$	$\theta = 3.60$	$\theta = 12.86$
Distance [0, 375)	−3.10	45.39	136.51	27.25
Distance [375, 750)	−3.66	55.67	176.74	32.97
Distance [750, 1500)	−4.03	62.77	206.65	36.85
Distance [1500, 3000)	−4.22	66.44	222.75	38.82
Distance [3000, 6000)	−6.06	108.02	439.04	60.25
Distance [6000, maximum]	−6.56	120.82	518.43	66.54
Shared border	0.30	−3.51	−7.89	−2.27
Shared language	0.51	−5.99	−13.25	−3.90
European Community	0.04	−0.44	−1.02	−0.29
EFTA	0.54	−6.28	−13.85	−4.09

EK(2002)

Geographic Barrier Estimates (effect on d_{ni})

Source of Barrier	Estimated Geography Parameters	Implied Barrier's % Effect on Cost $\theta = 8.28$	$\theta = 3.60$	$\theta = 12.86$
Destination country:				
Australia	0.24	−2.81	−6.35	−1.82
Austria	−1.68	22.46	59.37	13.94
Belgium	1.12	−12.65	−26.74	−8.34
Canada	0.69	−7.99	−17.42	−5.22
Denmark	−0.51	6.33	15.15	4.03
Finland	−1.33	17.49	44.88	10.94
France	0.22	−2.61	−5.90	−1.69
Germany	1.00	−11.39	−24.27	−7.49
Greece	−2.36	32.93	92.45	20.11
Italy	0.07	−0.86	−1.97	−0.56
Japan	1.59	−17.43	−35.62	−11.60
Netherlands	1.00	−11.42	−24.33	−7.51
New Zealand	0.07	−0.80	−1.83	−0.52
Norway	−1.00	12.85	32.06	8.10
Portugal	−1.21	15.69	39.82	9.84
Spain	−1.16	14.98	37.85	9.40
Sweden	−0.02	0.30	0.69	0.19
United Kingdom	0.81	−9.36	−20.23	−6.13
United States	2.46	−25.70	−49.49	−17.40

EK(2002)

Counterfactuals

Suppose countries have income Y and share α is spent on the manufacturing (tradable) sector.

Consider two cases for labor market. Both change equations for (manufacturing) wages slightly

- Manufacturing labor supply is fixed ⇒ Manufacturing labor income changes only with wages
- Labor supply is fully mobile ⇒ as wages change, manufacturing labor supply changes

Need a measure to evaluate welfare using real GDP = Y_n/p_n^α (non-manufacturing is a numeraire):

$$\frac{\log RGDP'}{\log RGDP} = \frac{\log Y_n'}{\log Y} - \alpha \log \frac{p_n'}{p_n} \approx \overbrace{\frac{w_n' - w_n}{w_n}\left(\frac{w_n L_n}{Y_n}\right)}^{\text{income effect}} - \overbrace{\alpha \log \frac{p_n'}{p_n}}^{\text{price effect}}$$

Note with mobile labor the income effect disappears

Counterfactuals

Base parameters are as follows:

SUMMARY OF PARAMETERS

Parameter	Definition	Value	Source
θ	comparative advantage	8.28 (3.60, 12.86)	Section 3 (Section 5.2, Section 5.3)
α	manufacturing share	0.13	production and trade data
β	labor share in costs	0.21	wage costs in gross output
T_i	states of technology	Table VI	source effects stripped of wages
d_{ni}	geographic barriers	Table VII	geographic proxies adjusted for θ

Two counterfactuals

- Welfare losses from moving to autarky ($d_{ni} = \infty, \forall n \neq i$) from current trade ($d_{ni}$ as estimated)
- Welfare gains from moving to a frictionless world ($d_{ni} = 1$) or doubling trade

Welfare Losses from Moving to Autarky

THE GAINS FROM TRADE: RAISING GEOGRAPHIC BARRIERS

	Percentage Change from Baseline to Autarky					
	Mobile Labor			Immobile Labor		
Country	Welfare	Mfg. Prices	Mfg. Labor	Welfare	Mfg. Prices	Mfg. Wages
Australia	−1.5	11.1	48.7	−3.0	65.6	54.5
Austria	−3.2	24.1	3.9	−3.3	28.6	4.5
Belgium	−10.3	76.0	2.8	−10.3	79.2	3.2
Canada	−6.5	48.4	6.6	−6.6	55.9	7.6
Denmark	−5.5	40.5	16.3	−5.6	59.1	18.6
Finland	−2.4	18.1	8.5	−2.5	27.9	9.7
France	−2.5	18.2	8.6	−2.5	28.0	9.8
Germany	−1.7	12.8	−38.7	−3.1	−33.6	−46.3
Greece	−3.2	24.1	84.9	−7.3	117.5	93.4
Italy	−1.7	12.7	7.3	−1.7	21.1	8.4
Japan	−0.2	1.6	−8.6	−0.3	−8.4	−10.0
Netherlands	−8.7	64.2	18.4	−8.9	85.2	21.0
New Zealand	−2.9	21.2	36.8	−3.8	62.7	41.4
Norway	−4.3	32.1	41.1	−5.4	78.3	46.2
Portugal	−3.4	25.3	25.1	−3.9	53.8	28.4
Spain	−1.4	10.4	19.8	−1.7	32.9	22.5
Sweden	−3.2	23.6	−3.7	−3.2	19.3	−4.3
United Kingdom	−2.6	19.2	−6.0	−2.6	12.3	−6.9
United States	−0.8	6.3	8.1	−0.9	15.5	9.3

Notes: All percentage changes are calculated as $100 \ln(x'/x)$ where x' is the outcome under autarky ($d_{ni} \rightarrow \infty$ for $n \neq i$) and x is the outcome in the baseline.

EK(2002)

Welfare Gains from Reducing Trade Costs

THE GAINS FROM TRADE: LOWERING GEOGRAPHIC BARRIERS

	Percentage Changes in the Case of Mobile Labor					
	Baseline to Zero Gravity			Baseline to Doubled Trade		
Country	Welfare	Mfg. Prices	Mfg. Labor	Welfare	Mfg. Prices	Mfg. Labor
Australia	21.1	−156.7	153.2	2.3	−17.1	−16.8
Austria	21.6	−160.3	141.5	2.8	−20.9	41.1
Belgium	18.5	−137.2	69.6	2.5	−18.6	68.8
Canada	18.7	−139.0	11.4	1.9	−14.3	3.9
Denmark	20.7	−153.9	156.9	2.9	−21.5	72.6
Finland	21.7	−160.7	172.1	2.8	−20.9	44.3
France	18.7	−138.3	−7.0	2.3	−16.8	15.5
Germany	17.3	−128.7	−50.4	1.9	−14.3	12.9
Greece	24.1	−178.6	256.5	3.3	−24.8	29.6
Italy	18.9	−140.3	6.8	2.2	−16.1	5.7
Japan	16.6	−123.5	−59.8	0.9	−6.7	−24.4
Netherlands	18.5	−137.6	67.3	2.5	−18.5	65.6
New Zealand	22.2	−164.4	301.4	2.8	−20.5	50.2
Norway	21.7	−161.0	195.2	3.1	−22.9	69.3
Portugal	22.3	−165.3	237.4	3.1	−22.8	67.3
Spain	20.9	−155.0	77.5	2.4	−18.0	−4.4
Sweden	20.0	−148.3	118.8	2.7	−19.7	55.4
United Kingdom	18.2	−134.8	3.3	2.2	−16.4	28.5
United States	16.1	−119.1	−105.1	1.2	−9.0	−26.2

Notes: All percentage changes are calculated as $100\ln(x'/x)$ where x' is the outcome under lower geographic barriers and x is the outcome in the baseline.

EK(2002)